

University of Wollongong - Research Online

Thesis Collection

Title: Evaluating university teaching and learning in an outcome-based model: replanting Bloom

Author: Maureen Mary Morris

Year: 2008

Repository DOI:

Copyright Warning

You may print or download ONE copy of this document for the purpose of your own research or study. The University does not authorise you to copy, communicate or otherwise make available electronically to any other person any copyright material contained on this site.

You are reminded of the following: This work is copyright. Apart from any use permitted under the Copyright Act 1968, no part of this work may be reproduced by any process, nor may any other exclusive right be exercised, without the permission of the author. Copyright owners are entitled to take legal action against persons who infringe their copyright. A reproduction of material that is protected by copyright may be a copyright infringement. A court may impose penalties and award damages in relation to offences and infringements relating to copyright material.

Higher penalties may apply, and higher damages may be awarded, for offences and infringements involving the conversion of material into digital or electronic form.

Unless otherwise indicated, the views expressed in this thesis are those of the author and do not necessarily represent the views of the University of Wollongong.

Research Online is the open access repository for the University of Wollongong. For further information contact the UOW Library: research-pubs@uow.edu.au

2008

Evaluating university teaching and learning in an outcome-based model: replanting Bloom

Maureen Mary Morris
University of Wollongong

Follow this and additional works at: <https://ro.uow.edu.au/theses>

University of Wollongong

Copyright Warning

You may print or download ONE copy of this document for the purpose of your own research or study. The University does not authorise you to copy, communicate or otherwise make available electronically to any other person any copyright material contained on this site.

You are reminded of the following: This work is copyright. Apart from any use permitted under the Copyright Act 1968, no part of this work may be reproduced by any process, nor may any other exclusive right be exercised, without the permission of the author. Copyright owners are entitled to take legal action against persons who infringe their copyright. A reproduction of material that is protected by copyright may be a copyright infringement. A court may impose penalties and award damages in relation to offences and infringements relating to copyright material.

Higher penalties may apply, and higher damages may be awarded, for offences and infringements involving the conversion of material into digital or electronic form.

Unless otherwise indicated, the views expressed in this thesis are those of the author and do not necessarily represent the views of the University of Wollongong.

Recommended Citation

Morris, Maureen M, Evaluating university teaching and learning in an outcome-based model: replanting Bloom, PhD thesis, School of Mathematics and Applied Statistics, University of Wollongong, 2008.
<http://ro.uow.edu.au/theses/784>

NOTE

This online version of the thesis may have different page formatting and pagination from the paper copy held in the University of Wollongong Library.

UNIVERSITY OF WOLLONGONG

COPYRIGHT WARNING

You may print or download ONE copy of this document for the purpose of your own research or study. The University does not authorise you to copy, communicate or otherwise make available electronically to any other person any copyright material contained on this site. You are reminded of the following:

Copyright owners are entitled to take legal action against persons who infringe their copyright. A reproduction of material that is protected by copyright may be a copyright infringement. A court may impose penalties and award damages in relation to offences and infringements relating to copyright material. Higher penalties may apply, and higher damages may be awarded, for offences and infringements involving the conversion of material into digital or electronic form.

**Evaluating University Teaching and Learning
in an Outcome-Based Model:
Replanting Bloom**

A thesis submitted in fulfilment of the
requirements for the award of the degree

DOCTOR OF PHILOSOPHY

from the

UNIVERSITY OF WOLLONGONG

By

Maureen Mary Morris

Bachelor of Science/Diploma of Education, University of Western Sydney

Master of Arts (Pure Mathematics), Sydney University

School of Mathematics and Applied Statistics

2008

Declaration

In accordance with the regulations of the University of Wollongong, I, Maureen Mary Morris, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy in the School of Mathematics and Applied Statistics, University of Wollongong, is my own original work, except where due references are made. It has not been submitted for a degree at any other university.

Maureen Mary Morris

Abstract

This thesis was inspired by an experienced teacher's desire to enhance student learning through implementation of a teaching/learning framework focused on promotion of higher order cognition. Two case studies document the construction, implementation and evaluation of learning frameworks for two disparate undergraduate university subjects.

Structurally, the thesis falls into three component parts. In the first, the researcher has reviewed the literature for an appropriate methodology, grounded her understanding of student learning through examination of relevant learning theories, canvassed suitable pedagogical strategies before construction of the teaching/learning frameworks, and devised an evaluation framework. In the second part, the two case studies have been described and in the final part, the threads of evidence have been drawn into the conclusion.

Action research afforded an appropriate methodology for the study. It offered facility for a spiral of implementation, review and re-implementation. Bound as a practitioner by the pragmatic perspective of *what works*, the researcher engaged multiple methodologies (grounded research encompassing elements of phenomenology and ethnography) in both case studies. She adopted a mixed method approach, with evidence derived from assessment data, survey responses, her annotated journal and comments from collaborating teachers and students.

The researcher's primary intent was to construct *aligned* teaching/learning frameworks that promoted contextualised thinking for students in the two disciplines. Judgment of the effectiveness of the resulting frameworks in enhancing student learning required a strict evaluative regimen.

Key issues percolated through the thinking of the researcher/teacher:

- *life-long learning*;
- *meta-cognition* and *deeper learning*; and

- marking of assessment that recognises achievement of learning objectives, offers students task related feedback and does not merely represent an aggregation of marks for ranking of students along a curve.

Therefore, strategies were included that fostered independent learning and promoted productive collaboration, while marking criteria formed the focus for aligning marking with the objectives.

The primary case study examined teaching and learning in a foundation course in statistics at the University of Wollongong in Australia. The intent was to foster *statistical thinking* in students. Experienced in the field, the teacher assumed an active role as a participant researcher. In consultation with discipline experts and innovative teachers, the researcher/teacher observed the existing environment for a single session (N=159). Learning objectives were then rigorously scrutinised and behaviourally reframed; objectives were specified for learning and assessment tasks; and marking criteria devised to scaffold student responses, check assessment for objective achievement and provide detailed and task related feedback. Thus the objectives formed the agents of *constructive alignment*.

Implementation of the selected strategies was tracked over the subsequent four sessions (cohorts ranging in size from 152 to 192 students). Evidence of student learning and the effectiveness of the framework was derived from:

- assessment marks and grades;
- deconstruction of assessment tasks and responses using the revised Bloom's Taxonomy (Anderson and Krathwohl, 2001);
- student survey responses;
- teacher and marker survey responses;
- the researcher's journal, annotated by collaborative teachers; and
- peer discussions.

Results have highlighted increases in mean marks in summative assessment accompanied by shifts to higher order cognitive demand in assessment tasks across the implementations. Furthermore, strong correlations between proportions of students reporting confidence in topic learning and exam performance have lent credence to the teacher's claim that *students know what they know and know what they do not know*.

The aim of the second case study was the design and implementation of an aligned curriculum for a subject focused on promoting *critical and evaluative thinking* in undergraduate accounting students. Although not the teacher/researcher's field of expertise, intense consultations with the subject designers produced behaviourally framed objectives and a teaching/learning framework that targeted the desired skills. This case study consisted of a single implementation (N=223). Results were not conclusive, but examination of the detail has provided fresh insight into the potential value of peer evaluation and student portfolios to address the desired thinking.

Comparison of the two case studies has highlighted the marked similarity between the teacher's expectations of *statistical thinking*, which underpins the University of Wollongong subject, and *critical and evaluative thinking*, which underpins the University of Western Sydney subject. 'Structure' has been identified as essential to successful implementation of the frameworks targeting discipline *thinking*. The structure of the desired thinking needs not only to be modelled but also to be recognised by students before it is effectively assimilated.

The researcher's journey has required reflective practice that includes both telescopic and microscopic review of her thinking, her habits and the action and reaction occurring within her classroom. The evaluation of student learning undertaken in this thesis has formalised the teacher's informal and intuitive response to the ostensibly absurd behaviours that take place as her students learn. Her deconstruction and interpretation of the apparent incongruities has at once affirmed past practice and inspired its renewal.

Acknowledgements

Although the onus of research is predicated on a journey of solitary thought, and the researcher is proud of her accomplishment, she acknowledges that this thesis has emerged in an environment redolent with support. She wishes to thank her supervisors for their encouragement, ideas and criticisms. Professor David Griffiths' humour, intellect and expertise with a red pen have spurred this writer to aim high and to treat the English language with the respect it richly deserves. Dr Anne Porter is an inspired educator who has fired the researcher with her enthusiasm for teaching statistics and treated this teacher as a valued colleague.

Born of parents who perceived education and independent thought to be more precious than wealth, brother, Denis and sister, Colleen have fuelled the drive to gain the competitive edge in academic achievement. Their encouragement, founded in expectation and belief in my ability, has been immeasurable.

I thank my children who have come to view Bloom as an annoying cousin who came to dinner and refused to leave. A gifted writer, Patrick has served many hours in review of my ideas and now regards himself expert on Bloom's taxonomy. Peter's training as a teacher has both been supported by his secondment as an evaluator of my theoretical perspectives and repulsed by the volume of those ideas. My daughters Louise and Kate have shown great restraint in turning a blind eye to their mother's housekeeping and have encouraged their eccentric mother in her academic pursuits. Louise's assistance with typing is appreciated as the researcher acknowledges her 'one finger' entry of this entire thesis has been daunting.

I thank my husband who has long since lost touch with my ideas and become accustomed to an absent minded wife and the invading dust mites that occupy the vast piles of rejected copy.

I acknowledge Anne Harper, Melissa Bennett, David Guy and Joe Tiziano who have provided the technological expertise that has saved this thesis from destruction on numerous occasions. I thank my friends Carole, Elahe, Raed and Rebecca (among others) who have suffered the same struggle to produce a thesis.

Last, but not least, I acknowledge the profound support provided by Emmie, Toby, Moghul and Georgie, my spaniels. They have suffered every tragedy and shared every joy in this epic journey. They have blindly accepted my idiosyncrasies and treasured my time with them as though it was for their benefit alone. Their companionship and their provision of the warmth of their bodies have saved me from cold and loneliness in the long periods of solitude.

Table of Contents

<i>Declaration</i>	i
<i>Abstract</i>	ii
<i>Acknowledgements</i>	v
<i>Table of Contents</i>	vii
<i>Tables</i>	xvi
<i>Figures</i>	xviii

Chapter 1

An Introduction

Informing practice: in pursuit of the elusive white rabbit

<i>“Down the rabbit hole” (Carroll, 2002, pp. 3-5)</i>	1
1.0 INSPIRATION: TEACHING IN WONDERLAND	3
1.0.1 Active teaching: a watching brief	3
1.0.2 Undertaking the quest	6
1.1 INTENTIONS	6
1.1.1 Research design: addressing the 'ologies	7
1.1.2 Defining learning	8
1.1.3 A blueprint for learning	9
1.1.4 Evaluation: a blueprint for detecting learning	10
1.2 RATIONALISATION	10
1.2.1 An innovation or a renovation?	11
1.2.2 A job worth doing?	12
1.2.3 At journey's end?	12
1.3 FRAMING THE PURPOSE: AIMS AND OBJECTIVES	12
1.4 ORGANISING THE NARRATIVE	14

Chapter 2

Methodology: A case to answer?

<i>“Which dreamed it? (Carroll, 2002, pp. 237-238)</i>	15
2.0 QUALITATIVE RESEARCH: A VIEW FROM INSIDE THE RAT'S MAZE	16

2.0.1 Behind the teaching: a teacher's perspective of knowledge	17
2.0.2 Selecting the research paradigm	19
2.0.3 Fit to purpose: the aims and objectives	19
2.1 MARRIAGE OF CONVENIENCE- EVIDENCE FROM PRACTICE	23
2.1.1 Why not experiment?	23
2.1.2 Mixed methods	24
2.2 CASE STUDIES	25
2.3 SELECTED METHODOLOGIES	26
2.3.1 Action research	29
2.3.2 Phenomenology	30
2.3.3 Ethnography	32
2.3.4 Grounded research	32
2.3.5 Evaluation research	33
2.4 PARTICIPANT RESEARCHER	36
2.5 ETHICS	37
2.6 LIMITATIONS	38

Chapter 3

Learning: Now you see it...or do you?

<i>Tweedledum and Tweedledee (Carroll, 2002, pp.161-163)</i>	40
3.0 WHAT IS LEARNING?	41
3.1 LEARNING THEORIES	41
3.1.1 Behaviourism	42
3.1.2 Cognitive learning theory	45
3.1.3 Constructivist theory	46
3.1.4 And deeper still: Co-constructivist theory	47
3.1.5 Experiential learning	49
3.1.6 Finding a paradigm: an eclectic compromise?	52
3.2 LEARNING TAXONOMIES	56
3.2.1 Bloom's Taxonomy	56
3.2.2 SOLO Taxonomy	60
3.2.3 A contextualised approach to classification?	64
3.3 LEARNING STYLES	64
3.4 STATISTICAL LEARNING	65
3.4.1 Defining the learning	66
3.4.2 Classifying the learning	70

3.5 FROM LEARNING TO INSTRUCTION	73
----------------------------------	----

Chapter 4

Teaching for learning: as easy as falling off a horse!

<i>"It's my own invention" (Carroll, 2002, p. 208)</i>	74
4.0 INSTRUCTING TO CONSTRUCT DESIRED LEARNING	75
4.1 DEFINING CONCEPTS	75
4.1.1 <i>Meta-cognition</i>	75
4.1.2 <i>Deeper learning</i>	77
4.1.3 <i>Organisers</i>	78
4.1.4 <i>Scaffolding</i>	80
4.1.5 <i>Alignment</i>	82
4.2 ASSESSMENT	84
4.2.1 Awarding marks and grades: summative assessment	87
4.2.2 Informing students: formative assessment	89
4.2.3 Norm versus criterion based assessment	92
4.2.4 Assessing specific learning: critical thinking	94
4.2.5 Assessing learning in statistics	95
4.3 CONSTRUCTING LEARNING	98
4.3.1 Collaborative learning	98
4.3.2 Technology	101
4.3.3 Authentic tasks	102
4.3.4 Active participation	103
4.3.5 Motivation	104
4.3.6 Marking criteria	102
4.3.7 Feedback	108
4.3.8 Learning portfolios	110
4.3.9 Peer evaluation	110

Chapter 5

Evaluation

Learning from teaching: Looking for atoms of meaning

<i>"Alice's evidence" (Carroll, 2002, pp. 104-105)</i>	112
5.0 REALITY IN THE QUALITATIVE STUDY	114

5.0.1 Situating the researcher	115
5.0.2 What happened and how do we <i>know</i> it?	116
5.0.3 Trees from the wood? Chasing <i>atoms</i> of meaning	117
5.1 PROGRAM EVALUATION	118
5.1.1 Evaluation models	121
5.1.2 The Context Input Process Product Model	121
5.1.3 Metfessel-Michael Paradigm	122
5.1.4 A Four stage evaluation of teaching and learning	123
5.1.5 An evaluation model for educational innovations	124
5.2 DEVELOPING A MODEL FIT TO PURPOSE	125
5.2.1 Logic behind the program: mapping perspectives	125
5.2.2 Focusing the evaluation	128
5.2.3 Evaluation criteria: the search for <i>atoms</i> of meaning	131
5.2.4 An adapted evaluation model	134
5.3 THE TEACHING/LEARNING FRAMEWORK: SUB-ATOMIC EVIDENCE	140

Chapter 6

Case Study

Doing the sums- improving a student's perspective of statistics

<i>"Queen Alice" (Carroll, 2002, p. 221)</i>	141
6.0 BACKGROUND	142
6.0.1 A need to encourage more students in the study of statistics	142
6.0.2 An aim for the study	143
6.0.3 A methodology	144
6.1 DESCRIPTIVE DETAIL	145
6.1.1 A time and place...	145
6.1.2 Working with experts	146
6.1.3 Working with novices	146
6.1.4 Content and skills	146
6.2 AN EXISTING INFRASTRUCTURE	147
6.2.1 Lectures	147
6.2.2 Laboratory classes	148
6.2.3 Assessment	148
6.2.4 Evaluation	149
6.2.5 Learning to tread in expert footsteps	149

6.3 PROMOTING LEARNING: ENHANCING THE FRAMEWORK	150
6.3.1 Defined learning outcomes	151
6.3.2 Marking guides as agents of scaffolding and feedback	152
6.3.3 Collaborative Learning	153
6.3.4 Experiential Learning	155
6.3.5 Authentic Tasks	155
6.3.6 The laboratory manual as a portfolio of learning	155
6.4 A SUBJECT IN PARALLEL	157
6.5 EVALUATION STRATEGY	157
6.5.1 Describing the <i>evaluand</i>	158
6.5.2 Seeking evidence: the annotated journal	159
6.5.3 Seeking evidence: peer review	159
6.5.4 Seeking evidence: student surveys	160
6.5.5 Seeking evidence: student assessment	163
6.6 TRACKING THE EVIDENCE: THE TEACHING/LEARNING FRAMEWORK	164
6.6.1 The impact of <i>lectures</i> on student learning	166
6.6.2 The impact of <i>laboratory</i> classes on student learning	167
6.6.3 The impact of the <i>laboratory manual</i> on student learning	167
6.6.4 The impact of <i>laboratory tasks</i> on student learning	168
6.6.5 The impact of the <i>solutions</i> on student learning	170
6.6.6 The impact of the <i>assignments</i> on student learning	172
6.6.7 The impact of the <i>lecture notes</i> on student learning	176
6.6.8 The impact of the <i>marking guides</i> on student learning	177
6.6.9 The impact of the midterm on student learning	178
6.6.10 The impact of the <i>online lecture</i> notes on student learning	179
6.6.11 The impact of <i>teamwork</i> on student learning	179
6.6.12 The impact of the <i>tutor</i> on student learning	180
6.6.13 The impact of the <i>learning strategies</i> on student learning	181
6.6.14 The impact of the specified <i>objectives</i> on student learning	182
6.6.15 The impact of the <i>online forums</i> on student learning	182
6.6.16 The impact of the <i>text book</i> on student learning	183
6.6.17 Students' general comments	183
6.7 TRACKING THE EVIDENCE: OVERALL LEARNING	184
6.7.1 The students' perspective: discipline learning	184
6.7.2 The students' perspective: graduates attributes	185
6.7.3 The students' perspective: overall learning	187
6.7.4 The teacher's perspective: the marks	188

6.7.5 From the researcher/teacher's perspective: the exams	191
6.8 CONCLUSIONS	193
6.8.1 Achievements	193
6.8.2 Deficiencies highlighted during the implementation	194
6.9 NEW PATHS TO TREAD	195
6.9.1 Peer review and its impact upon meta-cognition	195
6.9.2 Timing is of the essence!	196
6.9.3 Classifying learning: working backwards	196

Chapter 7

Case Study

Making sense of nonsense – an excursion into critical thinking

<i>"The Mock-Turtle's Story" (Carroll, 2002, p. 78)</i>	197
7.0 BACKGROUND	198
7.0.1 Uncharted territories	198
7.0.2 Answering the critics	198
7.0.3 A dilemma: addressing shallow learning in accounting students	199
7.0.4 Setting aims for the study	199
7.0.5 A methodology	200
7.1 ENVIRONMENTAL DETAIL	200
7.1.1 The teachers	200
7.1.2 The students	200
7.1.3 The subject delivery	201
7.1.4 The assessment regimen	201
7.2 DEFINING THE LEARNING	202
7.2.1 <i>Deeper learning</i>	202
7.2.2 Defining the subject learning outcomes	204
7.3 A PEDAGOGICAL FACELIFT	205
7.3.1 Scaffolding learning: rejuvenating tutorial classes	205
7.3.2 Promoting learning: engagement in meaningful tasks	206
7.3.3 Promoting learning: collaboration	206
7.3.4 Promoting learning: peer evaluation	207
7.3.5 Promoting learning: portfolios	208
7.4 REFINING THE ASSESSMENT	209
7.4.1 The assessment structure	209

7.4.2 The marking criteria	210
7.5 EVALUATION: SEEKING EVIDENCE	213
7.5.1 Student surveys	213
7.5.2 Student assessment	214
7.5.2 Peer review	214
7.6 CHECKING THE LEARNING: STUDENT SURVEY	214
7.6.1 Student survey: attendance patterns	216
7.6.2 Student survey: importance of subject presentation to learning	216
7.6.3 Student survey: perception of learning	218
7.6.4 Student survey: topic learning	219
7.6.5 Student survey: perceptions of achievement of subject outcomes	220
7.6.6 Student survey: experience of group work	221
7.7 ASSESSMENT	222
7.7.1 Formative assessment	222
7.7.2 Summative assessment	223
7.8 REFLECTIVE DISCUSSION: IMPACTING ON STUDENT LEARNING	227
7.8.1 <i>Deeper learning</i>	227
7.8.2 Collaborative learning	229
7.8.3 Peer evaluation	229
7.8.4 Student portfolios	229
7.8.5 Active student engagement	230
7.8.6 Marking criteria	230
7.8.7 Alignment through the objectives	231
7.9 CONCLUSION	232

Chapter 8

Conclusions

<i>"All in golden afternoon" (Carroll, 2002)</i>	233
8.0 REVISITING THE EVIDENCE	234
8.0.1 Focused teaching	235
8.0.2 Enhanced learning	236
8.0.3 Aligned assessment	238
8.0.4 Constructive alignment	239
8.0.5 <i>Statistical thinking</i>	240
8.0.6 <i>Critical and evaluative thinking</i>	241

8.1 FUTURE EXPLORATION	242
8.1.1 Classifying learning	242
8.1.2 Transparent objectives	243
8.1.3 Supported learning	244
8.1.4 Assessing learning	245
8.1.5 Evaluating the learning experience	246
8.2 IMPROVING LEARNING BY IMPROVING TEACHING	247
REFERENCES	250
APPENDICES	269
3.1a Table of classifications of ‘lower order’ knowledge types and cognitive processing skills according to the revised Bloom’s Taxonomy	269
3.1b Table of classifications of ‘higher order’ knowledge types and cognitive processing skills according to the revised Bloom’s Taxonomy	270
3.2 Models of Statistical Reasoning	271
5.1 The Metfessel-Michael Paradigm	272
5.2 The Four Step Evaluation Model	274
5.3 An integrated evaluation framework (adapted from Alexander & Hedberg, 1994)	275
6.1 STAT131: Aspects of <i>lectures</i> and associated student survey responses across all implementations	278
6.2 STAT131: Aspects of <i>lab classes</i> and associated student survey responses across all implementations	279
6.3 STAT131: Aspects of <i>lab manual</i> and associated student survey responses across all implementations	281
6.4 STAT131: Aspects of <i>lab tasks</i> and associated student survey responses across all implementations	283
6.5 STAT131: Aspects of <i>solutions</i> and associated student survey responses across all implementations	284
6.6 STAT131: Aspects of <i>assignments</i> and associated student survey responses across all implementations	285
6.7 STAT131: Aspects of <i>lecture notes</i> and associated student survey responses across all implementations	286
6.8 STAT131: Aspects of <i>marking guides</i> and associated student survey responses across all implementations	287
6.9 STAT131: Aspects of <i>midterm</i> and associated student survey responses across all implementations	288
6.10 STAT131: Aspects of <i>online lecture notes</i> and associated student survey responses across all implementations	289
6.11 STAT131: Aspects of <i>teamwork</i> and associated student survey responses across all implementations	290
6.12 STAT131: Aspects of <i>tutor</i> and associated student survey responses across all implementations	291
6.13 STAT131: Aspects of <i>learning strategies</i> and associated student survey responses across all implementations	292
6.14 STAT131: Aspects of <i>objectives</i> and associated student survey responses across all implementations	293
6.15 STAT131: Aspects of <i>forum</i> and associated student survey responses across all implementations	294

6.16	STAT131: Aspects of <i>text</i> and associated student survey responses across all implementations	295
6.17	STAT131: Facets of the teaching/learning framework and student survey responses to perceived importance to learning across all implementations	297
6.18	STAT131: Changing aspects of <i>student evaluation surveys</i> across all implementations	298
6.19	STAT131: Proportions of students responding as moderately confident or confident in topic learning across surveyed implementations	299
6.20	STAT131: Percentages of students believing they made progress toward achievement of the graduate attributes across surveyed implementations	300
6.21	STAT131: Descriptives for all assessment across all implementations	301
6.22	Final exam marks: Significant post hoc comparisons of paired means for final marks (equal variances not assumed – Tamhane and Dunnett T3)	302
6.23	Final exam marks: Significant post hoc comparisons of paired means for final marks (equal variances assumed – Bonferroni))	302
6.24	Percentages of students reporting progress in achievement of <i>graduate qualities</i> by <i>thinking statistically</i>	303
6.25	A sample student survey used in spring 2005	304
6.26	Percentage of marks allocated to questions on bivariate relationships (regression/correlation) in the autumn 2003 final exam (classified using the revised taxonomy of Bloom)	315
6.27	Percentage of marks allocated to questions on bivariate relationships (regression/correlation) in the autumn 2004 final exam (classified using the revised taxonomy of Bloom)	316
6.28	Percentage of marks allocated to questions on bivariate relationships (regression/correlation) in the autumn 2005 final exam (classified using the revised taxonomy of Bloom)	317
6.29	Classification of knowledge types and processing skills	318
6.30	Example of STAT131 Assignment 1	319
6.31a	Coding of examination questions (correlation of quantitative variables) using the revised taxonomy of Bloom (see Appendix 6.29) - Autumn Session 2003	326
6.31b	Coding of examination questions (correlation of quantitative variables) using the revised taxonomy of Bloom (see Appendix 6.29) - Autumn Session 2004	330
6.31c	Coding of examination questions (correlation of quantitative variables) using the revised taxonomy of Bloom (see Appendix 6.29) - Autumn Session 2005	334
7.1a	Subject presentation (<i>lectures</i>) before and after implemented changes with associated student survey responses (n=150)	338
7.1b	Subject presentation (<i>tutorials</i>) before and after implemented changes with associated student survey responses (n=150)	339
7.1c	Subject presentation (<i>web resources</i>) before and after implemented changes with associated student survey responses (n=150)	341
7.2	Subject assessment before and after implemented changes with associated student mark summaries (N=223)	343
7.3	Student subject evaluation survey	345
7.4	Spring 2005 Final Exam and teacher/marker comments	354

Tables

1.1	Objectives of the case studies incorporated in this thesis	13
2.1	Research paradigms	21
2.2	Choices of Methodologies for the classroom studies	27
2.3	Research design	28
2.4	Addressing criteria for judging the quality of the qualitative research in this study	34
3.1	Situating the researcher's teaching/learning framework	54
3.2	Condensed version of the Cognitive Domain of the Taxonomy of Educational Objectives	58
3.3	Two-Dimensional Cross-Classification of Types of Knowledge by Cognitive Processing Skills	59
3.4	Two-Dimensional Sub-cross-classification of <i>Conceptual</i> Knowledge by Cognitive Processing Skill: <i>Understand</i>	60
3.4	Isomorphic mapping of Piaget's Stages of Cognitive development to the SOLO descriptions	61
3.5	Classification of student responses to the above algebra questions using the SOLO taxonomy	63
3.7	Classifying statistical learning: the three domains	72
4.1	Example of an <i>organizer</i> for exploring the relationship between two variables	79
4.2	Example of <i>scaffolding</i> for exploration of a linear relationship between two numeric variables	81
4.3	Indicators of effective assessment	86
4.4	Sample objectives for an assignment assessing a linear relationship between two quantitative variables	105
4.5	Example of marking criteria for an assignment assessing a linear relationship between quantitative variables	106
5.1	Multiple perspectives and potential evidence sources	118
5.2	Focusing the evaluation	129
5.3	Focus questions for developing the evaluation framework	130
5.4	A general <i>comlist</i> for the objectives of this study	132
5.5	An example of an expansion (of checkpoint 1.1 of Table 5.4) of the general <i>comlist</i>	134
5.6a	An integrated evaluation framework for both case studies for the <i>Observation Phase</i>	136
5.6b	An integrated evaluation framework for both case studies for the <i>Development Phase</i>	137
5.6c	An integrated evaluation framework for both case studies for the <i>Implementation Phase</i>	138
5.6d	An integrated evaluation framework for both case studies for the <i>Review Phase</i>	139
5.7	Focus detail of the teaching/learning framework	140
6.1	Implementation cycles of STAT131 included in this study	144

6.2	Focusing the evaluation of the learning framework for STAT131	158
6.3	Student survey responses for each implementation	161
6.4	Student enrolment for the observation phase and each implementation	161
6.5	Failure rates (%) across all implementations	171
6.6	Percentages of students reporting that <i>teamwork worked well</i> across all implementations	173
6.7	Submission rates for assignments across all implementations	173
6.8	Percentage of students reporting belief in exam preparedness after completing all set tasks across all implementations	187
6.9	Percentage of students reporting belief in <i>statistical learning</i> across all surveyed sessions	188
6.10	Percentage of students reporting perception of subject relevance across all surveyed sessions	188
6.11	Percentage representation of cognitive demand of final exams autumn 2003, autumn 2004 and autumn 2005 (regression question)	192
7.1	Redefinition of the learning objectives 2005	204
7.2	Essay Marking Criteria for Accounting Theories and Philosophies	212
7.3	Aspects of the teaching/learning framework ranked by percentage of students perceiving them as moderately to extremely important to their learning (N=150)	216
7.4	Percentage of students responding to overall subject learning (N=150)	218
7.5	Confidence in topic learning ranked by percentage of students	219
7.6	Perceived competence in objective achievement ranked by percentage of students	221
7.7	Percentage of students reporting experience of group work (N=150)	222
7.8	Descriptive statistics for the continuous assessment	223
7.9	Pearson's correlation coefficient (r) for student assessment with their final exam marks	224
7.10	Descriptive statistics for exam questions (N=223)	225
8.1	Evaluation of aligned teaching	235
8.2	Evaluation of student learning	237
8.3	Evaluation of aligned assessment	238
8.4	Constructive alignment	239
8.5	Evaluation of <i>statistical learning</i>	240
8.6	Evaluation of <i>critical and evaluative thinking</i>	241

Figures

2.1	Diagrammatic representation of developmental trends in thinking and conceptions of teaching	18
2.3	Action research spiral	31
3.1	Expanding Kolb's learning cycle to include learning about learning	48
3.2	Kolb's learning cycle	51
3.3	Teaching/learning framework showing relevant learning theory inputs	55
3.4	Outcomes of statistics education	71
4.1	Two-Dimensional Sub-classification of <i>Meta-cognitive</i> knowledge	76
5.1	A logic model for the teaching/learning framework	127
6.1	Teaching/learning framework showing implemented strategy inputs	151
6.2	Comparison of reported Assignment 1 marks (scaled out of ten) with recorded assessment data across all implementations	162
6.3	Ranked order of the reported proportions of students perceiving surveyed facets as important to their learning (2002)	165
6.4	Distribution of marks for completed laboratory tasks for students achieving greater than 50% in the final exam	170
6.5	Comparison of mean marks for the three assignments across all implementations	174
6.6	Comparison of the distribution of assignment marks across all implementations	175
6.7	Boxplot of final exam marks across all sessions	189
7.1	Comparison of distributions of reported and actual Presentation marks from the assessment data file	215
7.2	Possible structure for lecture	228